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Beyond Shear Characterisation: Determining the Flexural Moduli of Engineering Fabrics Using a Modified Uniaxial Bias Extension Test

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The large deformation mechanics of biaxial engineering fabrics are of considerable interest due to the importance of sheet forming processes for the manufacture of advanced composite products and structures. The success or failure in forming a given geometry and the properties of the final composite component are in large part determined by the material's forming mechanics and consequently, a significant amount of time and effort has been devoted to characterising and modelling this behaviour.

The current work proposes a novel approach to determining the shear compliance [1], out-of-plane bending [2] and in-plane bending [3] response of engineering fabrics by combined use of the Pierce cantilever test [4] and a modified version of a simple, well-established shear test, widely used for mechanical characterisation of engineering fabrics; the uniaxial bias extension test. It will be shown that a modified uniaxial bias extension test can be used, not only to measure the shear resistance of the fabric (it's usual purpose), but also to evaluate both the out-of-plane and in-plane flexularal moduli of fabrics. In this way, only two simple test methods need to be employed in order to provide comprehensive evaluation of predictions of finite element forming models.

In order to demonstrate the approach a series of experimental tests have been conducted on a plain weave engineering glass fabric. The out-of-plane modulus is first determined using the Pierce cantilever test. Using the resulting out-of-plane flexural rigidity, the modified uniaxial bias extension test is modelled in finite element simulations (see, for example, Figure 1).

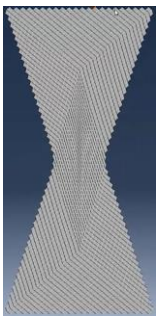

Figure 1. Finite element simulation of a uniaxial bias extension test.

A new modelling texhnique is introduced, able to incorporate shear compliance, out-of-plane bending and in-plane bending behaviour, in a simple, accurate and robust way. An estimate of

the shear compliance of the fabric is first obtained using established normalisation theory [5]. By then using an iterative, inverse modelling strategy, both the shear compliance and the in-plane bending modulus are more accurately obtained. The new testing methodology has the potential to become a simple tool for comprehensive evaluation of mechanical forming models for engineering fabrics.

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